Low Cost, High Efficiency, High Pressure Hydrogen Storage (New FY 2004 Project)

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Objectives

Deliver a cost-effective and safe high-pressure hydrogen storage system that will meet all of the DOE goals for compressed hydrogen storage

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Storage section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- A. Cost
- B. Weight and Volume
- E. Refueling Time
- H. Sufficient Fuel Storage for Acceptable Vehicle Range
- I. Materials

Approach

QUANTUM will develop and test an advanced, cost-effective, and safe high-pressure hydrogen storage system. The first task will be to choose the most appropriate fiber from which to construct the tank. The 3-dimensional or tri-axial composite material strength values will be generated for the baseline material. Small composite test bottles will be fabricated and burst tested. Strain gages will be mounted on the bottles to correlate burst pressure and composite wall stresses and strains. A detailed axisymmetric finite element analysis of each test bottle will be completed to correlate to the strain gage data obtained from the bottle burst tests. Composite specimens will be fabricated and tested to obtain the cross-ply compressive strength of the material.

A representative tank will be designed for 10,000 psi service pressure. A detailed finite element model that includes the metallic parts will be completed to assess the stress/strain state in the composite shell and metallic parts. Up to three tanks will be fabricated and burst tested to finalize the tank design for 10,000 psi. Three tanks will be fabricated and tested to demonstrate the scale-up capabilities of the material characterization and optimization. One tank will be burst tested, and two tanks will be cycle tested and burst tested at the end of cycle testing.

QUANTUM will work with Oak Ridge National Laboratory to identify a robust and cost-effective stress sensor technology that is suitable for integration on tanks. This sensor will allow the tank to operate at reduced stress ratios with the benefit of lighter weight.

A review of current tank Design Failure Modes and Effects Analysis will be completed to assess the critical issues and validation tests of a tank. Three tests will be specified to demonstrate the strength and life capabilities of the tanks. The three tests will be completed, and it is anticipated that the tests will include pressure cycling at ambient and elevated temperatures.

Tests will be conducted to better understand the thermodynamics of the tank charging and discharging process and to capitalize upon that understanding by optimizing fuel temperature and pressure and how that relationship is affected by additional insulation on the tank, on-board refrigeration, heat-sink technologies, fuel consumption rate and thermal load.

The analysis portion of the project will establish a working foundation upon which the development of a refueling refrigeration system design, on-board refrigeration system design, heat-sink system design, and tank insulation system design will be made. The analysis is meant to serve as both a guide for development as well as a means by which the fundamental thermal characteristics of the fuel and tank system can be understood and predicted. Most of the analysis will be built from first-principles.